THE HAT CREEK BAD LANDS.

BY J. S. KINGSLEY.

A WEEK to spare in the last part of May, railroad transportation available, and the Bad Lands of Nebraska accessible, —who could refuse the trip? The four who made up our party certainly could not. So we started, taking the train for Harrison, Sioux county, aiming to visit the little Bad Lands of the Hat Creek valley, for these were more easily reached than the larger Bad Lands of the White River, and besides they were not as well known or so much explored.

A week's trip is not much to write about, but in a week one can see a good deal, and then in a week the novelty of the strange scenes has not worn off, and the features of the wonderful landscape can be better described. No inhabitant of the West Indies could describe these striking features in such a striking manner as has the late Canon Kingsley. The Bad Lands are often mentioned, but as yet the descriptions of the regions are not numerous.

The journey from Lincoln was without event. First came the climbing out of the valley of Salt Creek, then the long, straight line of track for thirty-five miles, and next the descent into the valley of the Platte at Grand Island. The Platte is a strange stream. Geologically speaking, it is a new river, which has not yet been able to master its sediment. It is broad and shallow, and a deep hole is excavated only to be immediately filled by the shifting sands of the bottom. In dry seasons there are long stretches where no water is visible, but down in the sand the water is still running to the Missouri.

Across the Platte the railroad strikes for the Loup valley, crosses the South Loup, and follows up the fertile fields of Mud Creek. A little beyond Broken Bow the "sand hills" are reached, and through them for two hundred miles we ride. There is nothing picturesque in the landscape now. One can easily imagine himself among the sand dunes of Cape Cod or the New

Jersey shore. Yet these hillocks of shifting sand and scattered tufts of coarse grass are interesting, for in them we find evidence that this portion of Nebraska was not so treeless as it was when the first settlers entered it. As the sand blows it uncovers here and there the well-preserved trunks of pine trees. What could have caused their extinction? Certainly not change of climate, for in the cañons in this same region the same pine grows abundantly.

Beyond Alliance we cross the upper Niobrara, and the landscape again changes, for we have now to cross that long line of hill, Pine Ridge, which extends for over a hundred miles across the northwestern corner of the state. On the southern side there is nothing striking except the pine trees. These have a different habitus from pines in the east. In Maine and in Michigan the pines form dense forests; but here they are scattered like the spruces on a lawn. The train now goes through a tunnel, and we enter the valley of the White River. What a change in the landscape! It is no longer tame, but it is cut and eroded into the most fantastic shapes. To the north is the valley of the river,—here a small stream,—and from it the grassy slopes ascend gradually for several miles; then a more rapid rise, and then the Buttes. Look where you will, you see them. You are among them while far to the north. Clear across the White River you see the same formations. One cannot help thinking that here the process of world-making was suddenly interrupted.

From Crawford to Harrison we follow up the White River. We climb first to the foot of the Buttes; then above them to a broad, level prairie, much like those in the eastern part of the state. Here we find the town of Harrison, 5,000 feet above the sea, where we leave the cars and take a wagon for the Bad Lands.

For three miles north the road gradually ascends, and we strike the head of one of the cañons which are to lead us to the Hat Creek valley. Did I say we were above the Buttes? Even in this highest point we see here and there slight piles of rock, the last remnants of Buttes which once covered this region.

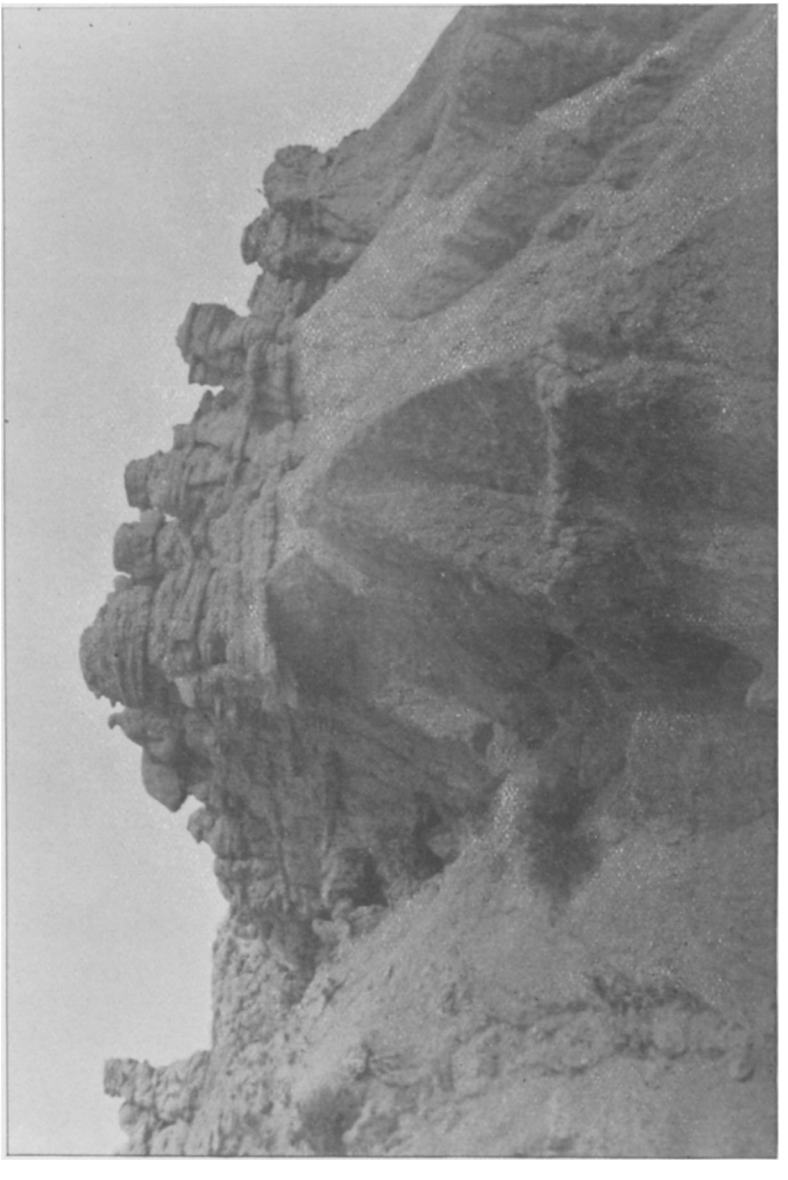
Down the cañon we go, three or four miles, thirteen hundred feet fall. Again we enter the line of Buttes. Those we saw before were the buttresses on the White River side of this divide; those we now see are those of the Hat Creek valley. Follow the horizon around, and everywhere there are the same fantastic forms, extending thirty or forty miles to the north. Away beyond them rise the dark outlines of the Black Hills, and towering above all is Harney's Peak, a hundred and twenty miles away. Halfway down the cañon we followed, came in a side cañon, and here were the most wonderful Buttes of all. In their outlines they reminded us of ruined castles, fortifications, and the like, on a gigantic scale. The lines of stratification of the creamy-white limestone resembled the courses of masonry, while the crevices cut the outline into buttresses, terraces, and embrasures. At the end of the cañon nearest us the resemblance was most striking. The corners were square cut, and the perpendicular walls were between a hundred and fifty and two hundred feet in height. Above them, in the center, towered another mass of rock, fifty feet or more,—just as did the keep in many a mediæval castle.

The broad valley of Hat Creek slopes gradually down from the Buttes, and as we first saw it it looked as if carpeted with grass. A closer glance at the vegetation showed us that here the buffalo grass was not extinct, while the cactuses and sage-bush showed that the land was none of the best. A most striking feature was the number and brightness of the flowers. A little white lily was everywhere, while the bright-colored "loco weeds" (Astragalus and Oxytropis) gave a variety. Throughout all the west these weeds are said to render the animals which feed upon them crazy or "locoed." There is a chance for some investigation here. One of the most striking of the flowers was a little Frittillaria, never before known to occur as far east as Nebraska. It is a graceful lily, with its petals nicely marked with yellow and a purplish brown. At Lincoln fully half the flowers were old acquaintances which I knew in the Atlantic states; but here, four hundred miles from Lincoln, every plant was a novelty. It was interesting to note how closely every plant hugged the earth, the sage-bush and the Spanish bayonet excepted.

As yet no Bad Lands. At last, as we rode along, one of the party, who had been there before, told us not to look up until he spoke. Three minutes passed, and then the signal came. We gazed on the most desolate spot I ever saw. For miles it was all the same. The names Bad Lands and its French equivalent, Mauvaises Terres, need no defense. Not a bit of green,—nothing but that creamy-white, calcareous, clayey rock; and this was not level and flat, but eroded into the most irregular surface one could imagine. Ridge and gully, ridge and gully succeeding each other for miles,—the summits of the ridge as sharp as the roof of a house, while the gullies in most instances were not wide enough to allow the passage of anything larger than a wheelbarrow. It was a magnificent chance to study erosion; but how was it eroded? The gullies were as dry as the crests of the ridges. Here and there we struck broader gullies, but even here soil was lacking and nothing green was to be seen. The light reflected from the creamy ground was very trying to the eyes, while the heat on a warm day was oppressive. Not a breeze finds its way into these narrow valleys. The walls sometimes rise at the angle of forty-five degrees; at others they are all but perpendicular. They vary from fifty to one hundred and fifty feet in height. The strata of which they are composed are not homogeneous. For the most part they can be easily cut with a knife; but here and there there are harder bands, and this alternation gives rise to strange erosion figures. The lower and softer strata wear away more rapidly than the upper and harder beds, and at one place the result was startlingly like a sitting man with a slouch hat. In places one finds vertical fissures filled with—now gypsum, now calcite.

These Bad Lands are most celebrated for the fossils they contain. In the higher levels of the Buttes fossils are scarce. I am told that they yield but few turtles, and nothing else. In these lower strata of the Bad Lands mammalian remains are abundant, as well as turtles. Some of these latter are small, scarcely three inches in length; some are veritable giants, the carapaces measuring nearly three feet by four. Turtle remains are very abundant. Some are as perfect as when the animal died, while others have

PLATE XX.



BAD LANDS OF HAT CREEK.

succumbed to the frosts and present the collector naught but disarticulated plates. The scarcity of turtle skulls is noticeable; our party collected only a lower jaw, while we found two turtle eggs, one in perfect condition. In one place the turtles presented an interesting phenomenon. They had resisted erosion better than the underlying stone, and as a result in a small area there were about a dozen turtles, each supported on a slender post about two feet above the surrounding surface, while there were as many more which had tumbled down and left the standard to disintegrate.

We had not sufficient time to carefully hunt for fossils and to take only the best, so we did but little digging. It is a tedious process to get a fossil out from its bed. The necessary apparatus consists of a picking hammer, a quantity of tough manilla paper, paste, and patience. When a fossil is found imbedded in the rock, the exposed portions are covered with paper pasted on, and then the paste is allowed to dry. Now more is uncovered with the pick; paper is pasted on again, and so on until the whole is separated from the rock. Excavated in this way the bones are kept in just the relations in which they were found, while the paper protects them from injury in transit. Instead we followed along the gullies searching for the fossils which had been weathered out, and when a portion was found we followed up the wall above it hunting for the rest of the animal. The result of this method of collecting was that we got quantities of fragments; but we also found considerable that was more complete, some of it valuable.

Most abundant of all the mammalian remains were the *Oreodons gracilis* and *major*. These were small animals about the size of a good-sized dog, unlike anything which now exists. Their line is extinct. In some of their features they resembled the pigs, and in others they were more like the ruminants.

Prof. Cope has recently shown their position in the conspectus of the vertebrates which he has published in this journal. He also published a synopsis of the Oreodontidæ in the Proceedings of the American Philosophical Society for 1884, while Prof. Scott, of Princeton, has a valuable and beautifully illustrated paper on them in the *Morphologisches Jahrbuch*, of later date. Other forms which occur more or less abundantly in these beds hardly agree with the fauna of Nebraska to-day. There are

bones which recall the camels and the alpacas; forms which are intermediate between the rats and the squirrels, and others which may be the granddaddies of the horse. Then there were still others which fed on these grass-eating species: tigers with enormous canine teeth, and the still larger Hyænodons with teeth which close together like shears. It was a wonderful fauna which inhabited Nebraska and Dakota in the ages long past.

Will the Bad Lands ever be exhausted of fossils? The treasures of this region and of the larger bad lands of Dakota adorn the museums of the east, and every year collectors are at work. Of course the specimens which are weathered out can soon be picked up, but there are quantities left. In fact, the beds may be said to be inexhaustible. Each spring a new crop may be expected. What has been the history of the region? How did all these animals accumulate here? What makes the land bad? Why is it not like disintegrating rock elsewhere? These are some of the questions. There are few problems in geology which give their answer in a plainer manner. It is a veritable classic and pony.

These regularly stratified beds, layer after layer of marly material, twelve or fifteen hundred feet in thickness, must have been deposited on the bottom of an inland sea, while the character of the fossils—for mollusks occur here and there—shows that the water must have been fresh. To-day these strata are nearly as level as when they were first laid down. The eye cannot detect any departure from the horizontal; and in the Buttes to the north can be traced layer for layer the same beds which occur in the Buttes to the south. There is, however, a slight dip in the strata caused by the upthrust of that strange mountain region, the Black Hills, to the north.

This lake drained the region around, but the geological history of all that region known as the plains shows that then, as now, the streams largely ran from west to east. Hence the principal affluents of this Miocene lake must have come from the west. The climate then was probably different from that to-day, for nowhere within two hundred miles is there rainfall sufficient to maintain such a lake as this.

On the shores of this lake and on the banks of the tributary streams lived those animals which supplied the fossils of to-day.

First and most abundant were the Oreodons and their allies. The number of their remains shows that they most probably formed large herds. Rarer were the horse-like forms, which, however, resembled but little the horses of to-day. Then there were camels and rhinoceroses, and largest of all the immense Menodus, the lower jaw of which measured about two feet in length. These animals fed on the vegetation, while the cats and Hyænodons of the time preyed on these. How the bodies were transferred to the place where we find the bones is a problem easily solved. Probably there were freshets caused by abundant rains, and numbers of animals were swept by the stream into the lake. Here the bodies floated about, disturbed by the gases of decomposition, until a part dropped here and another there. This explains the scattered condition of the bones to-day. Even in the solid rock it is unusual to find more than two or three bones together. Certain it is that these animals were not mixed where we find them.

At length the conditions changed. The lake still remained, gathering sediment at the bottom, but the mammalian remains are much scarcer than before, and even in the upper portions of these bad-land strata they are much less abundant than in the lower beds. What was the cause? I do not know. Still the lake continued laying down stratum after stratum until there was at least more than a thousand feet of rock piled upon the top of the fossils. How much more there was we do not know. The Buttes are our sole register in this respect. We no not know how much erosion there has been from their tops.

At last the lake became dry, and its old bottom was exposed to the air, and now erosion began. Looking across the Bad Lands from the tops of the Buttes, and seeing that valley forty or fifty miles across, and with an average depth of eight hundred or a thousand feet, one no longer wonders at the muddy Missouri or at the immense alluvial deposits which the Mississippi has made; and yet this same erosion is going on and has been going on at a thousand other places of equal extent.

Rapid erosion now ceased, and the broad valley with its gently undulating surface gained a soil. Then a second erosion began, and it is this second erosion which has produced the Bad Lands.

Here and there in this area we find a bit of what might be termed tableland or a small scale. The upper surface is covered with a scanty vegetation of buffalo grass, cacti, sage-brush, and *Agave angustifolia*, with the ever-present loco weeds. But the slopes of the tableland are abrupt, and not a bit of green can be found on them. The geological history of the region can be predicted. This erosion will go on until the ridges are all worn away, and the bad lands again become reduced to a plain. Then as Hat Creek wears a deeper channel, erosion will again be increased, and the Bad Lands will be repeated.

At first sight we all thought that the erosion was extremely rapid. The rock looks at first sight as if it would melt like sugar when it rained, but apparently this is not the case. My conclusions are that the winter frosts are the really efficient agents in the process. Rain and melting snow penetrate for an inch or two into the rock, and then the expansion of the freezing water disintegrates the outer surface of the rock, and it is only this outer portion which is soft. We found a place where for two years an irrigating ditch had emptied itself into the Bad Lands. It had nearly washed away this outer softened layer. The solid rock showed no signs of wear.

In studying erosion in this region one must remember that here the rainfall is not excessive. Some ten or fifteen years ago Prof. Samuel Aughey published some charts and tables, the object of which was to show that the rainfall was increasing rapidly in Nebraska. The lines on his maps were as firmly drawn as the contour lines in a topographical survey. But alas! there is no evidence, nor has there ever been, to support these charts and these conclusions drawn from them. The annual rainfall is given or regions and times when there were no observations and no one there to observe. To-day our statistics are scanty, and now reach back far enough to enable us to say whether the annual rainfall is increasing at all. Apparently from the slight data we have in the Bad Land region a rainfall of sixteen inches in a year is unusual. With that slight amount extensive erosion is not probable.

The question is asked, Will these Bad Lands ever be of value? Not in the immediate future. A country so extremely irregular is not available for agriculture. A few years ago this whole

region was occupied by cattle rangers, and thousands of heads were to be found here. Here and there, flowing down from the cañons, are small streams which afforded water, while in the dry climate the grass cures on the ground and is available for pasturage the whole year round. Rarely are the snows sufficiently deep to prevent the animals feeding in the open field. A few years ago the region was preëmpted by settlers. The cattle were driven out, and to-day the barb-wire fence shows the limits of the farms. But these farmers have a sorry time of it. No rain, no crops. I should not be surprised to see the whole country go back to grazing.

Owing to various circumstances we had but twelve hours' actual collecting time; and we went over but a corner, some six miles across, of the Bad Lands. Not much could be expected in so short a time and in such hurried and superficial collecting, yet when we got back to the railroad and packed our fossils we found that all four had obtained over 450 pounds. A list of the species we obtained would prove dry, but a rapid examination of the fossils showed some thirty or forty species represented by fragments or more complete remains.

Of animals we found comparatively few traces. The region is not such as to support an extensive fauna. We were told that mountain lions, timber wolves, and coyotes were comparatively common. In the Bad Lands and in the country surrounding we found several skulls and a good many horns of the buffalo. Horned toads are comparatively common in the whole region. The cacti form a habitation for a true cochineal insect; but to me the most surprising find was a scorpion in the Bad Lands. I did not suppose that they occurred nearer than Southern Kansas and Colorado, three or four hundred miles nearer the equator.

One of our party was an entomologist, and he obtained numerous good things on the trip. One evening, as we were making up our beds in the open air, we were completely covered by a small June bug. The entomologist told us that the species was described but a few years before from specimens which he collected. Scarcely half a dozen specimens represented the species in all the collections of the world. He took hundreds of specimens away with him.